WBS 4
The Electromagnetic Calorimeter

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DOE/NSF Review
May 19, 1998

Outline

- System Overview
- US responsibilities
- Cost Estimate
- Changes Since Last Review
- Commitment and Resource Profiles
- Changes since last review
- Status and Progress
- Organization
- Schedule
- Response to Recommendations
- Summary and Conclusions

WBS 4.0 Institutions

Caltech:

J. Bunn, Q. Deng, A. Favara, P. Galavez, M. Gataullin, J. Hansen, A. Kirkby, L. Mossbarger, H. Newman, S. Shevchenko, A. Shvorob, R. Wilkinson, L. Y. Zhang, R. Zhu.

Fermilab

John Elias.

Northeastern University

G. Alverson, J. Moromisato. Y. Musienko, Th. Paul, S. Reucroft, D. Ruuska, J. Swain, L. Taylor, E. Von Goeler, T. Yasuda

Univ of Minnesota

P. Border, P. Cushman, A. Heering, K. Heller, B. Patel, R. Rusack, C. Timmermans, P. Vikas.

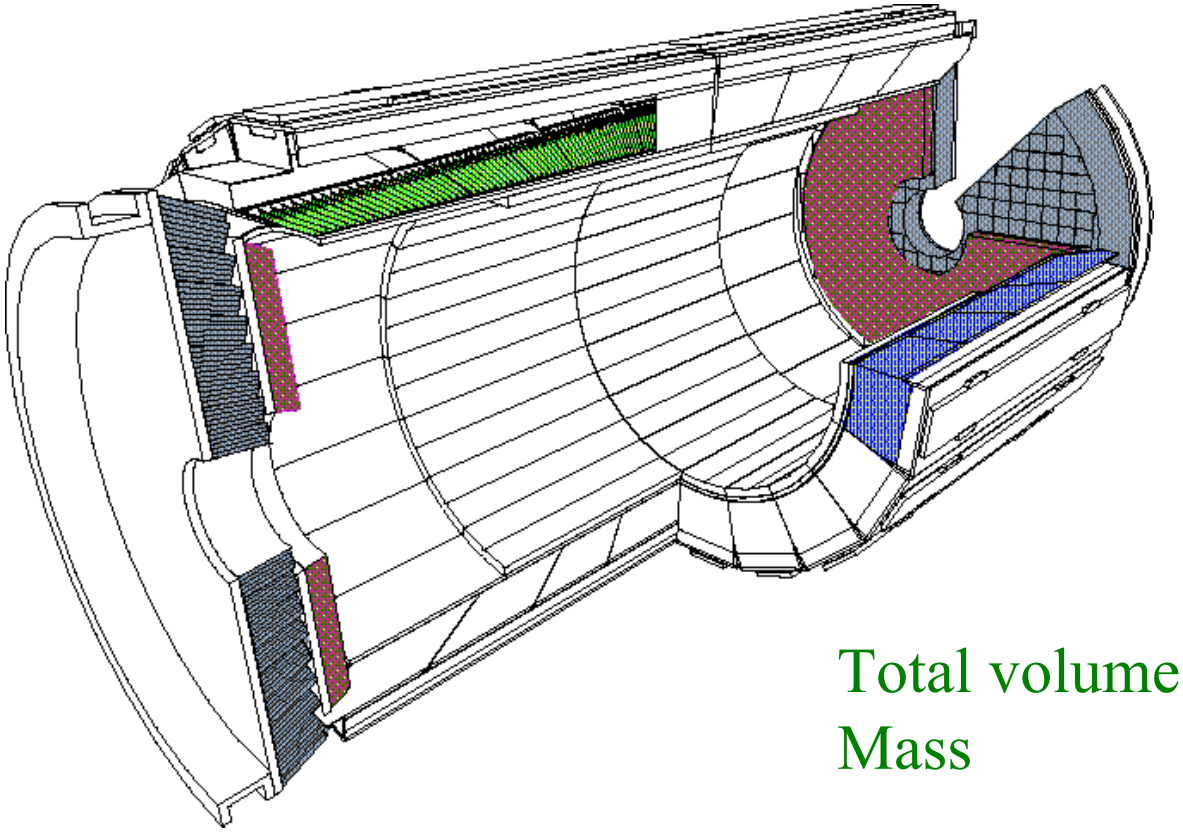
Princeton University

P. Denes, V. Gupta, D. Marlow, P. Piroue, D. Stickland, H. Stone, C.Tully, R. Wixted.

The Electromagnetic Calorimeter

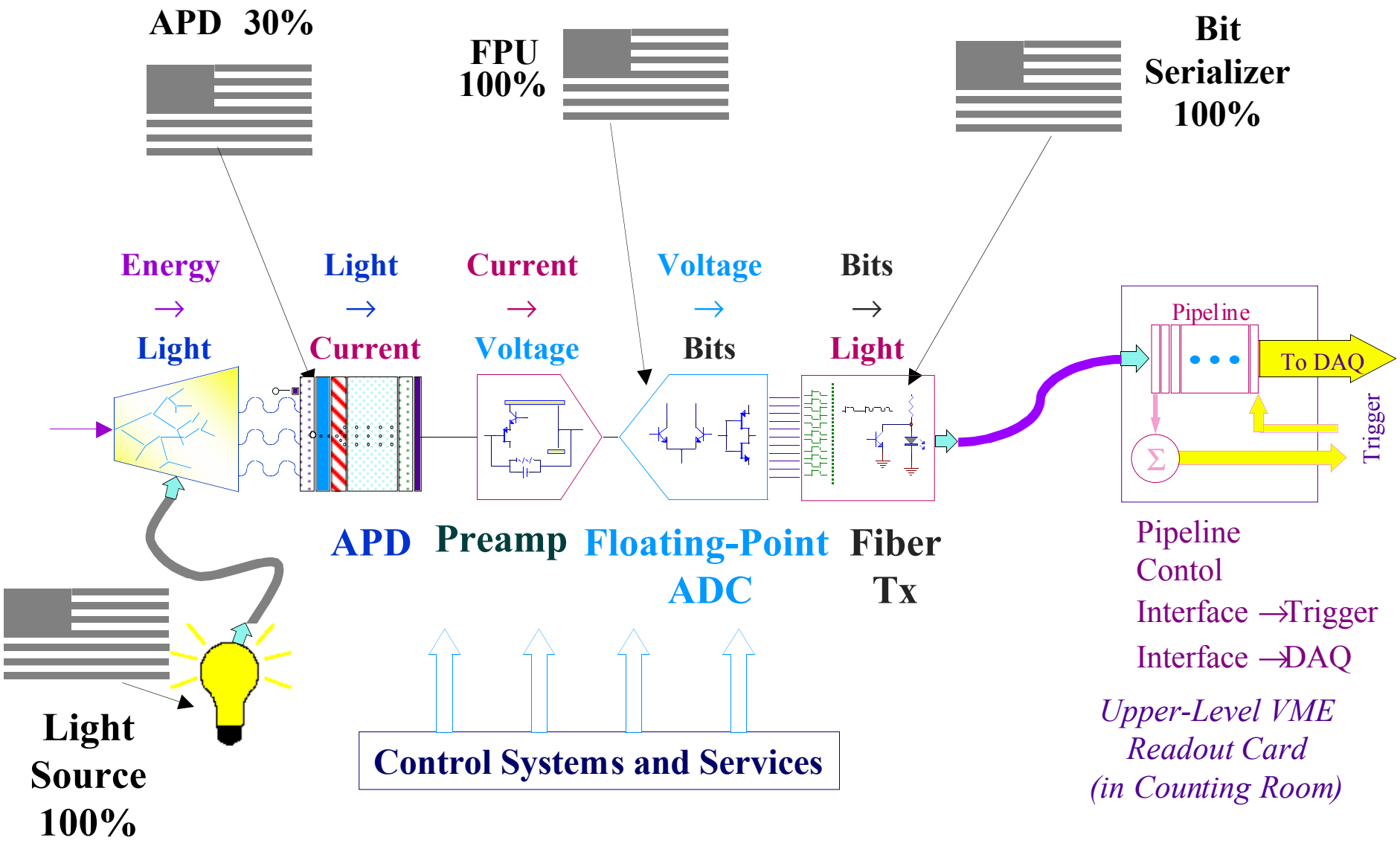
The CMS electromagnetic calorimeter will be built with Lead Tungstate crystals.

61,200 in the barrel and 21,528 in the end-caps.
Barrel: Inner Radius 1.238m, Length 6.340 m
25.8 X_o in barrel and 24.7 X_o in the end-caps.



Total volume 11.24 m^3.
Mass 96.2 t

US Responsibilities



Deliverables - Overview

4.1 Avalanche Photodiodes — US Contribution

- 4.1.1 & 2 Prototypes - and small scale production of avalanche photodiodes. (50%)
- 4.1.3 Pre-production APD's for 1,000 crystals. (30%)
- 4.1.4 Calibration Station - Design, procure and install (50%)
- 4.1.5 Procurement - APD's for 61,200 crystals. (30%)
- 4.1.6 Stability Study - Design and perform study (100%)

4.2 Barrel Electronics

- 4.2.1 FPU & Support ASIC - Design and procure (100%)
- 4.2.2 ADC - R&D and Pilot Program. (100%)
- 4.2.3 Power Supply R&D - Design low voltage bias (100%)
- 4.2.4 FiberOptic Readout-Design and Procure Bit-Serializer (100%)
- 4.2.5 Readout Card (PCB) - Design and Procure (100%)

4.3 Monitor Light Source

- 4.3.3 Light Source - Design, procure and install (100%)
- 4.3.4 Optical Switch - Design, procure and install (100%)

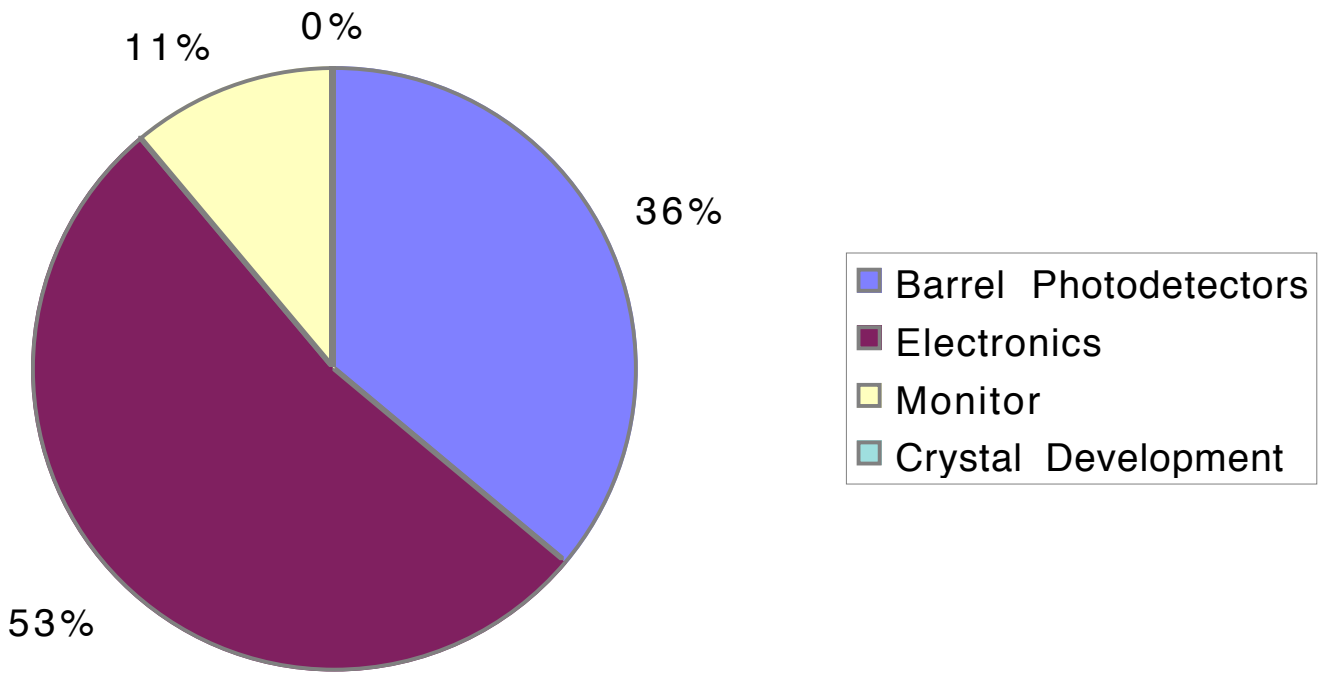
4.4 Crystal R&D

- 4.4 R&D on the Lead Tungstate Crystals.

ECAL Cost Estimate ($M)

Base: $7.2M Contingency: $3.6M (50%)

Total Estimated Cost (FY97 $): $10.7M



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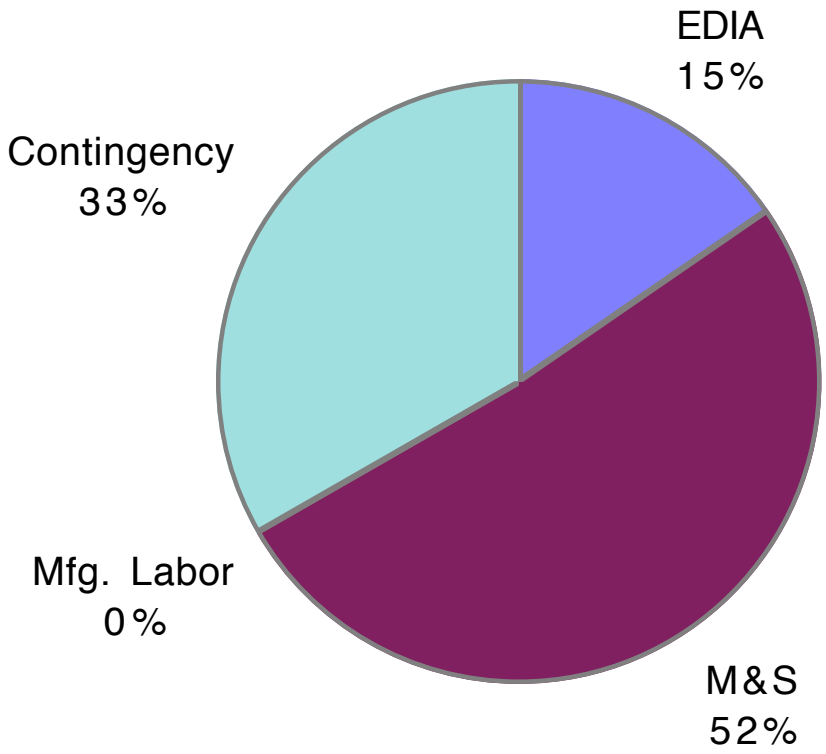


Major Technical Changes

- Electromagnetic Calorimeter:
  - ⇒ Reduction radius of calorimeter diameter from 1420 mm to 1290 - reduces crystal volume by 15% and number of readout channels by 30%. Done to meet costs - Consequence: Increase in signal to noise.
  - ⇒ Move pipeline electronics from behind to crystals to outside of the detector and bring out 40 MHz signal from every crystal - Reduces system failure risk and the material between ECAL and HCAL.
- 4.1 Avalanche Photodiodes - Increase area of APD's from 25 to 50 mm^2.
- 4.2 Electronics - CHFET bit-serializer introduced to drive optical link.
  - FPU and preamplifier merged to same ASIC.
- 4.3 Monitor Light Source - None.
- 4.4 Crystal R&D - None.

Major US Scope Changes

- Crystal End-face Polisher has been removed
  - We will use a Russian/CERN system instead of the polisher from LLNL.

- Thermal Finite Element Analysis has been removed
  - A model of the crystal, electronics and cooling is being used to evaluate cooling system's performance at CERN.

- 4.1- The number crystals equipped with APD's decreased from 28,000 to 18,000
  - Overall system reduction in scope.

- 4.2 - Number of readout channels reduced from 88,000 to 61,020
  - Overall system reduction in scope.

- 4.3 - No changes.

- 4.4 - No changes.

Technical and Project Status.

- TDR submitted to CERN 12/97.
- Crystal Production beginning in 1998.
- Complete 1,000 channel complete rad-hard electronics chain by end of 1998

- US L3 project status.

  - 4.1 APD's: R&D complete. Final NRE phase to begin.
  - 4.2 Electronics: Engineering submissions this year.
  - 4.3 Monitor Light Source: Detailed Design started.
  - 4.4 Crystal R&D: Final Stages.

Management

- Each component of the US project has a level 3 manager:

4.1 Avalanche Photodiodes….	S. Reucroft	(Northeastern)
4.2 Electronics……	P. Denes	(Princeton)
4.3 Monitor……..	R. Zhu	(Caltech)
4.4 Crystal R&D……	R. Zhu	(Caltech)

- Each Institution submits a Statement of Work detailing tasks to be undertaken by the institution during the FY.
- All DOE funded institutes have opted for MPO via Fermilab as the fastest way of getting funds.
- Caltech will charge no overhead against the project.
- Princeton only on first $25k

Organization

Communication between the three L3 projects is relatively simple - frequent meetings at CERN and in the US.

Recent meetings:

Minnesota - 12/97, CERN - 3/98, Fermilab - 4/98.

Efficient communication between US effort and ECAL effort is assured by Peter Denes (Princeton).

He is based full-time at CERN and is the Electronics Coordinator for the ECAL sub-detector.

Schedule

- Milestones:

  Major milestones of ECAL are defined by CMS.

  Relevant milestones for US-ECAL are:

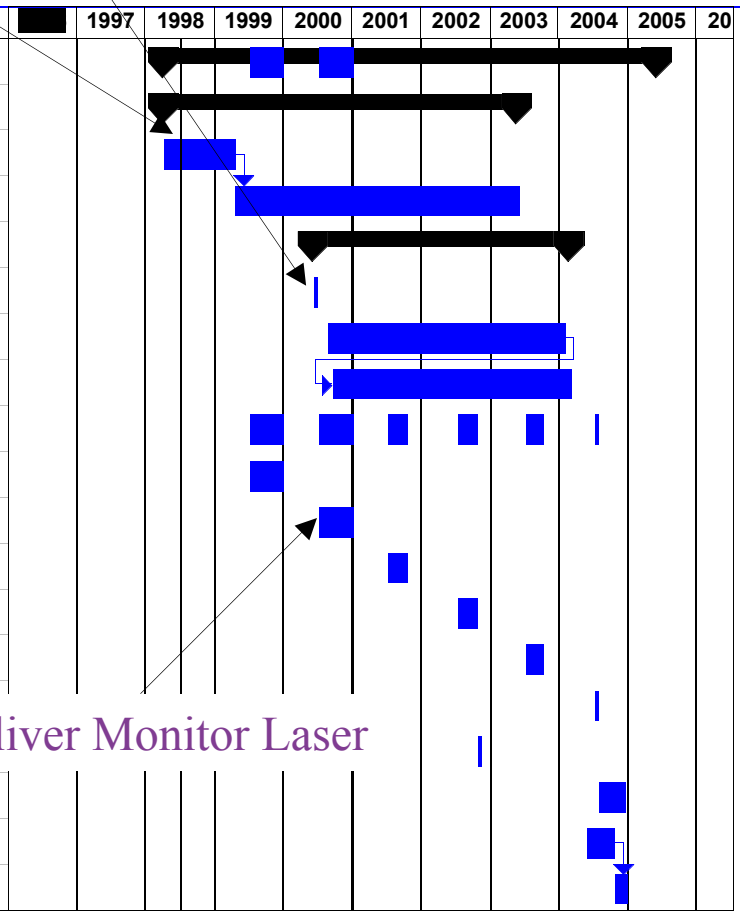
APD Technology Decision	June 1998.
Delivery of Laser Light Source	April 2000
Complete Calibration of first 12 supermodules	Sept 2001
Complete Installation of ECAL	Sept 2004

Construction Schedule.

APD's & Electronics in production

1000 crystal pre-production

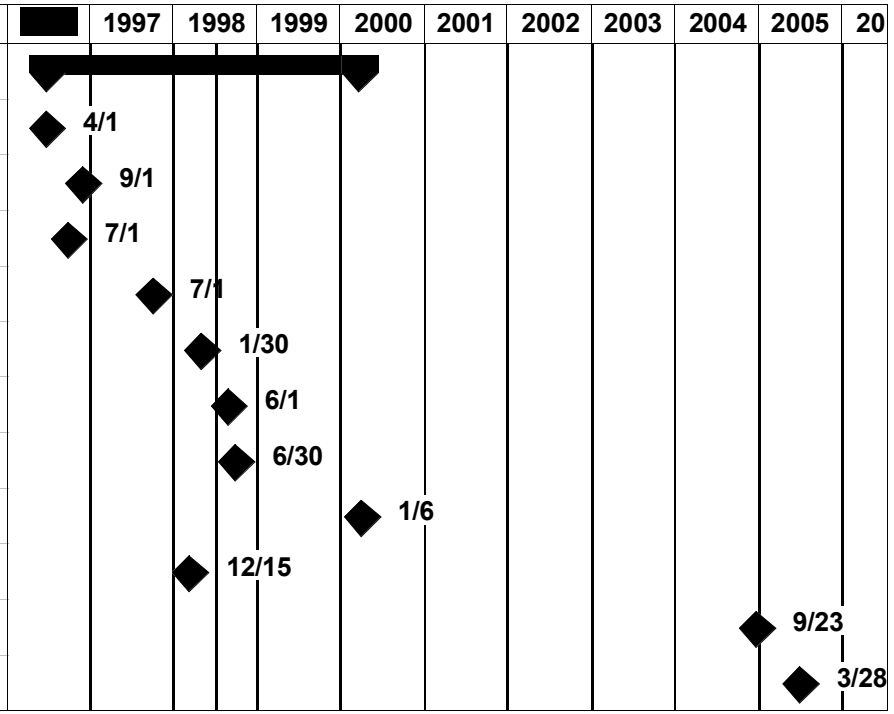
ID	Task Name
24	**Construction, Calibration and Installation**
25	**Crystals**
26	Pre-production
27	Production for barrel
28	**Assemble the supermodules**
29	Assemble SM1
30	Reception of modules
31	Delivery of supermodules
32	**Beam Calibrate the supermodules**
33	Prepare the calibration
34	Beam Calibrate SM1
35	Beam Calibrate SM 2-12
36	Beam Calibrate SM 13-23
37	Beam Calibrate SM 24-33
38	Beam Calibrate SM 34-36
39	Beam Calibrate Dee 1
40	Beam Calibrate Dee 2-4
41	Install/test the Barrel
42	Test the complete barrel



Deliver Monitor Laser

APD Milestones

ID	Task Name
11	*APD's*
12	*Hamamatsu Series "B" APD*
13	*EG&G Low k APD*
14	*Hamamatsu Series "C" APD*
15	*EG&G "Thick" / New Pkg APD*
16	*Budgetary Estimates for APD Program*
17	*Firm Fixed Quotes for production APD's.*
18	*APD Technology Selection*
19	*Award Contract for APD's*
20	*TDR*
21	*Install tracker*
22	*Complete beam pipe instalation*



Response to Recommendations

Obtain a quantitative understanding of the long-term reliability of APD's and VFE electronics as soon as possible.

We are currently testing some 200 APD's from both EG&G and Hamamatsu. Next step will be to test 2000 APD's. We will build a 1000-channel demonstrator of the front-end chain.This will run without crystals, but be subjected to thermal stress, and (parts of it) operation under irradiation.

Explore commercially available test methods that may yield good reliability data in addition to the planned extensive burn-in of the first 1,000 channels.

Standard industry practice for Silicon components is that operation at 85°C under bias, corresponds to an acceleration of aging by a factor of 100.

Summary

- The ECAL subsystem has reduced scope to meet the available resources.
- A TDR has been presented to CERN and has been recommended for approval by the LHCC to the CERN research board.
- The US-ECAL groups have dropped two tasks to reduce costs.
- New “Bottoms up” cost estimate based entirely on a resource-loaded schedule.
- Significant technical progress made in past year.